

extends from the trench to a field region creating an electrical contact to the metal layer and providing continuity from the metal layer to the trench.

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54. A semiconductor device as in Claim 32, further comprising an electrical contact to the gate region, the drain region and simultaneously to the body region and the source region.

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55. A semiconductor device as in Claim 54 wherein a horizontal cross section of said semiconductor body has a polygonal shape.

66. A semiconductor device as in Claim 54 wherein a horizontal cross section of said semiconductor body has a substantially circular shape.

#### REMARKS

Claims 17-53 were pending prior to this amendment. Claims 54-66 are newly presented. Claims 17, 30-32, 36-37, 41-42, 46, 52, and 53 are amended to further define Applicants' invention. Claim 43 is canceled.

The Examiner rejected Claim 36 under 35 U.S.C. § 112, fourth paragraph, as being of improper dependent form stating that Claim 36 depends from itself. Applicants respectfully submit that the Examiner is mistaken. Claim 36 recites that it depends from Claim 34.

The Examiner rejected Claims 31, 41, 42, 43, 52 and 53 under 35 U.S.C. § 112, second paragraph. Claim 43 is now canceled. As amended, Applicants believe that Claims 31, 41, 42, 52 and 53 have overcome the Examiner's rejection. Accordingly, reconsideration of Claims 31, 41, 42, 52 and 53 is requested.

The Examiner rejected Claims 17-29 under 35 U.S.C. § 103

over Tonnel (U.S. Patent 4,420,379). In response to Applicants' Preliminary Amendment, filed on May 30, 1995, the Examiner continued to maintain his previous assertion that Tonnel's VMOS transistor is a trench DMOS transistor, notwithstanding that it is well-known in the art that the "V" in the acronym "VMOS" refers to the transistor's "V" shape slot and not to its function as a vertical transistor. As amply discussed in Applicants' Preliminary Amendment of May 30, 1995, Applicants' claims 17-29 each recite a device having fundamentally different electrical characteristics distinguishable from Tonnel's VMOS transistor. In order to expedite prosecution of the pending, Applicants have now amended Claim 17 to particularly recite a topological difference between the recited device and Tonnel's VMOS transistor:

a trench formed in said epitaxial layer, having substantially vertical side walls, extending from said top surface of said epitaxial layer to a depth  $d_{tr}$ , said depth  $d_{tr}$  being less than said depth  $d_{max}$ , and greater than said depth  $d$ , said trench being (i) closer to said second location than said first location, and (ii) horizontally adjacent said source region. (emphasis added)

By contrast, Tonnel's VMOS transistor has side walls which are each slanted at an angle from the vertical and which meet at an acute angle at the bottom of the V-slot. Because the device recited in Claim 17 does not have side walls meeting at an acute angle, as in the case of Tonnel's VMOS transistor, the device in Claim 17 has far superior oxide dielectric breakdown characteristic over Tonnel's VMOS transistor. The deleterious effect of an acute angle at where the side walls meet on the oxide dielectric breakdown characteristic is discussed in Applicants' Specification, on page 9, lines 9-22 and on page 12, lines 17-34:

...A second problem is oxide dielectric breakdown. In a closed-cell geometry, the trench side wall oxide is grown under non-planar, two-dimensional conditions at intersections of trench

faces. This causes non-planar, viscous deformation and stress in adjacent gate oxide material. According to published theoretical and experimental evidence, the oxide that grows on the side walls of, for example, a square cell DMOS transistor is thinned and distorted at an intersection of two adjacent trench faces in a manner illustrated in Fig. 7. When these distortions are combined with conformal covering of the surface of gate material, the oxide profile may develop near-atomically sharp field concentration sites and may manifest premature dielectric breakdown.

...

In a horizontal cross-section, the trench side walls intersect at angles of approximately  $120^\circ$ , as compared to an intersection of  $90^\circ$  in a rectangular cell design. This offers a substantial improvement for two dimensional oxidation conditions as it reduce stress at the corners and promotes increased uniformity of oxide thickness. Further, the hexagonal corners may become rounded off during the trench mask lithography and etching processes that precede trench formation so that the DMOS cells approach the cylindrical shape of a natural, field-controlled current valve. A hexagonal cell, trench DMOS is expected to have a higher gate rupture breakdown voltage than does its rectangular cell counterpart. For transistor operation the trench shape, in horizontal cross section (plan view), may be a polygon (not necessarily regular) or a circle or an oval; but the regular hexagon and polygonal shapes approaching a circle are the preferred shapes from the point of view of minimizing the gate oxide rupture voltage.

Clearly, Tonnel's VMOS transistor, with its acute angle V-slot will "develop near-atomically sharp field concentration sites", which will induce breakdown to occur near the base of the V-slot, rather than moving the breakdown into the bulk, as would Applicants' device of Claim 17. Therefore, Applicants respectfully submit that Claims 17-29 are therefore patentable over Tonnel. Accordingly, withdrawal of the Examiner's rejection under 35 U.S.C. § 103, reconsideration, and allowance of Claims 17-29 are respectfully requested.

The Examiner rejected Claims 32, 33, 34, 35, 36, 43, 44, 46, 47, 48-49, 51, 52, and 53 under 35 U.S.C. § 103 as being unpatentable over considerations of Tonnel. As amended, Claims

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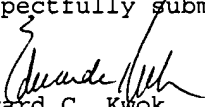
respect to Claim 17, Applicants believe that Claims 30, 32, 46, 52 and their dependent Claims 31, 33-45, 47-51 and 53 are similarly patentable over Tonnel. Thus, withdrawal of the Examiner's rejection under 35 U.S.C. § 103, reconsideration and allowance of Claims 32, 33, 34, 35, 36, 43, 44, 46, 47, 48-49, 51, 52 and 53 are respectfully requested.

Newly presented Claims 54-66 each also recite a trench having substantially vertical side walls. Thus these claims are believed allowable also.

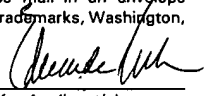
The Examiner rejected 17-53 under judicially established doctrine of double patenting over Patent claim 2 and its dependent claims in U.S. Patent 5,072,266. To overcome this rejection, Applicants will submit a terminal disclaimer when the Examiner indicates that these claims are patentable over the prior art of record.

For the foregoing reasons, Applicants believe that all claims (i.e. Claims 17-53) are allowable and respectfully request their allowance. If the Examiner has any questions regarding the above, the Examiner is respectfully requested to telephone the undersigned Attorney at 408-453-9200.

Respectfully submitted,

  
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I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C., 20231, on December 26, 1995

  
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